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Backwards Fading to Speed Task Learning

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14. ABSTRACT *(Maximum 200 words)*:
In Backwards Fading (BF), a learner is provided with an initial, complete demonstration of a multi-step task. In subsequent iterations, more and more of the later task steps are completed by the student. Thus, task performance shifts from the instructor to the student. BF can be understood as a systematic means of removing scaffolding across learning trials. Research indicates BF holds promise for effective/efficient training, but the utility of BF in Army settings and with Army tasks needs to be empirically evaluated. To that end, Soldiers (N = 215) participated in two experiments. In the first experiment, Soldiers were BF trained on tasks judged by SMEs to be of comparatively low or high complexity. In the second experiment, Soldiers were trained via gradual ('step') or accelerated ('block') BF on a cognitive or a procedural task. Results indicated that the BF approach was effective, with 'Go' rates ranging from 77% to 99% on all tasks. The data exhibited weak but consistent trends in the directions hypothesized: more complex tasks yielded poorer performance than less complex tasks (Experiment 1) and more accelerated BF resulted in poorer performance than gradual BF (Experiment 2). Recommendations for utilizing BF in Army settings are provided.

15. SUBJECT TERMS
Tailored training, Backwards fading, Tasks, Performance

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BACKWARD FADING TO SPEED TASK LEARNING

EXECUTIVE SUMMARY

Research Requirement:

The United States Army requires effective and efficient training. However, what is effective and efficient varies from group to group and individual to individual. Research indicates that prior knowledge is a major determinant of performance (Schmidt, Hunter, & Outerbridge, 1986; Schmidt & Hunter, 1992, 1993), with low prior knowledge individuals performing better with more scaffolding (i.e., instructional support) and high knowledge individuals performing better with less scaffolding (Kalyuga, Chandler, & Sweller, 1998). If a trainer is dealing with populations who are naïve (that is, there simply <u>is</u> no prior knowledge) with respect to a task, what is needed is a systematic method to move everyone from a naïve state to a more proficient state. One such method involves graduating individuals from worked examples to problem solving, with worked examples defined as providing learners with a complete demonstration of a multistep task and problem solving defined as the student completing the task from beginning to end without instructional support. An effective and efficient means of facilitating such a transition from examples to problem solving is known as *backwards fading* (BF; Renkl, Atkinson, Maier, & Staley, 2002).

Procedure:

Subject matter experts (SMEs) examined a number of different Army tasks to determine the feasibility of using backwards fading (BF) to train Initial Entry Training (IET) Soldiers in a variety of Army field settings (e.g., concurrent training during marksmanship qualification). The tasks chosen were both hands-on and cognitive in nature. Based on the task selection criteria, five (5) tasks were chosen. Four of the tasks were hands-on and the fifth task was cognitive. In Experiment 1, Soldiers (n = 120) received BF training on tasks that ranged in complexity. The goal was to see if judgments of task complexity based on SME judgment yielded results comparable to judgments of tasks whose complexity was more straightforwardly assessed, as is typical of the research literature. In Experiment 2, Soldiers (n = 95) received BF training in which Soldiers either gradually (*step* fading) or rapidly (*block* fading) assumed responsibility for performance without instructional support.

Findings:

Analyses revealed weak but largely consistent trends in the hypothesized directions. In Experiment 1, tasks judged more complex by SMEs exhibited higher error rates, lower Go rates, longer times to complete, and fewer completed steps (i.e., more unattempted steps) than tasks judged to be less complex. A similar, albeit less consistent, pattern held in Experiment 2: block faded tasks were performed more poorly than step faded tasks. Regardless of task condition, BF was largely successful: ‘Go’ rates ranged from approximately 77% to 99%. We discuss some potential theoretical interpretations of this pattern and propose some rules of thumb for determining whether BF is a viable training approach from situation to situation.

Utilization and Dissemination of Findings:

The findings demonstrate the potential utility of BF as a means of training Army relevant tasks in concurrent and other field training settings. The materials required for training this task can be quite minimal (depending on the task). These findings were briefed to the Battalion and Company Commanders of the 1-50th Infantry Battalion, 198th Infantry Brigade at Fort Benning, GA on March 19, 2013.

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Introduction

In recent years, operational tempo has required the United States (U.S.) Army to train more people in less time, placing an ever-increasing premium upon effective and efficient training. In many cases, this requires tailoring training to individuals who vary along learning-relevant dimensions, such as prior knowledge (Schaefer, Blankenbeckler, & Lipinski, 2011; Schmidt, Hunter, & Outerbridge, 1986). Sometimes, however, such tailoring of training is not feasible. For example, trainers often must teach tasks to individuals who simply have no prior knowledge of the tasks. What is needed in such situations is an efficient and effective means of transitioning learners from a naïve state to a more proficient state. When dealing with multistep tasks, such a transition can be accomplished by graduating learners from worked examples (complete demonstrations of all task steps) to problem solving (the learner alone performs all task steps) via *backwards fading* (BF; Renkl, Atkinson, Maier, & Staley, 2002).

Backwards Fading: What It Is, Why It Works

BF is the systematic removal of scaffolding (i.e., instructional support) across learning trials (Renkl, Atkinson, Maier, & Staley, 2002; Snow, 1992). In early learning trials, both the learner and the instructor (or the learner and a computer) are involved in performing task steps. In later learning trials, more and more of the task steps are performed by the learner alone. An example of the BF methodology is depicted in Figure 1.

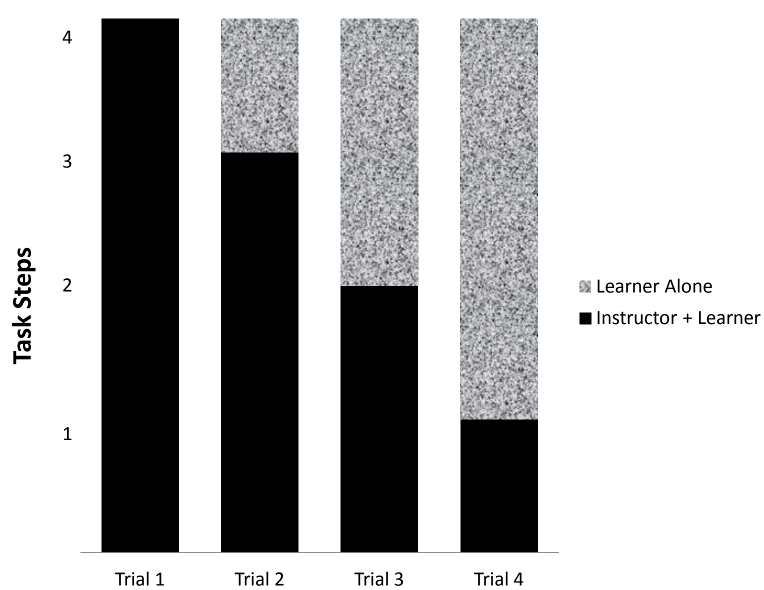

***Figure 1*. Example of backwards fading.**

On the first learning trial, both the instructor and the learner complete all four task steps. Thus instructional support is present throughout the first trial. On the second trial, the instructor and the learner both complete the first three task steps, but the fourth (last) task step must be

completed by the learner alone. On the third trial, both the fourth (last) and third (next to last) task steps must be completed by the learner alone. And so on, until the final learning trial is reached. So as learning trials progress, scaffolding is removed (or 'faded') beginning with the later task steps (hence 'backward' faded) until the task is mostly or entirely performed by the learner alone in the absence of instructional support.

Kalyuga, Chandler, Tuovinen, and Sweller (2001) used computers (not instructors) to present programming problems to novice mechanical trade apprentices. The novices were assigned to either a worked example or problem solving condition. In early learning trials, performance in the worked example condition was superior. In later learning trials, performance in the problem solving condition was superior. The authors interpreted this to mean that the scaffolding provided by the worked examples was helpful early in the learning process, but became redundant and eventually detrimental later in the learning process.

Renkl, Atkinson, Maier, and Staley (2002) and Renkl & Atkinson (2003) carried the worked examples vs. problem solving dichotomy to its logical conclusion. The authors argued that 'pure' worked example and problem-solving conditions were at opposite ends of a continuum. The authors further theorized that the goal of training was to gradually shift a person away from heavy reliance on the scaffolding provided by worked examples and towards a scaffold-free condition of problem solving. Terming this gradual shift a 'smooth transition', the authors compared performance under such a gradual shift to the performance gained by more traditional worked-example and problem solving pairs. Results indicated not only that the 'smooth transition' was superior to the worked example/problem solving pairs, but that BF was more efficient than 'forward' fading (i.e., on the second trial the learner performs the first task step, on the third trial the learner performs the first and second task step, etc.).

The theoretical explanation behind the efficiency and effectiveness of BF derives from *cognitive load theory* (CLT). CLT focuses on the roles that long term and working memory (WM) play in the learning process.[1] Although working memory is quite limited in some contexts (Miller, 1956), in other contexts its capacity is quite extensive. For example, when working in their fields of specialization, experts can handle vast amounts of complex information in working memory. The same is most definitely not true of novices. It appears that as one gains expertise in a domain, information is increasingly stored not only in working memory, but also in long term memory (Arocha & Patel, 1995; Bransford & Johnson, 1972; Chi, Glaser, & Rees, 1982; De Groot, 1966; Halpern & Bower, 1982; Kalakoski, 2008; Lambiotte & Dansereau, 1992). So as domain expertise increases, more and more working memory is freed up and less and less scaffolding is required. Consider how this dovetails with the BF procedure shown in Figure 1. In the first learning trial (that is, when task or domain knowledge is low and WM load is high), instructor assistance is at its peak. As learning trials proceed (and task or domain knowledge increases, leading to subsequent decreases in WM load), instructor assistance decreases. In short, BF is designed to remove instructor assistance as task or domain knowledge increases and more and more WM is freed up.

[1] Working memory stores the content of current, conscious awareness, while long term memory contains information to which we have access but are not currently aware. For a lengthier account of CLT, see Sweller, van Merrienboer, & Paas (1998).

Backwards Fading, Army Tasks, and Army Settings

There are two reasons to believe that BF may be a fruitful approach for training Army tasks. First, Renkl, Maier, Atkinson, and Staley (2002) successfully used BF via overhead transparencies and instructors. To put the point differently, BF can be implemented with little reliance on technology—an obvious selling point in an era of budget constraints and for training in environments that pose problems for heavy computer use (e.g., concurrent training conducted in dirty or wet conditions like a marksmanship range). Secondly, the theoretical explanation behind the effectiveness/efficiency of BF involves working memory, which is a well-supported psychological construct with broad explanatory power (Baddeley, 1992). Given the need to quickly master a wide variety of tasks, anything that minimizes strain on WM should benefit Soldier learning.

However, academic research on BF has largely focused on cognitive tasks, rather than applied, hands-on tasks typical of Army training settings (see Schaefer & Dyer, 2013). This research, routinely carried out in artificial or laboratory conditions, often increased the complexity of a task (e.g., by adding steps, increasing working memory load on any given step, etc.) to examine the theoretical relationship between task complexity, BF, and performance outcomes. Given that the goal of our research is to understand how BF can aid in the training of defined Army tasks in actual field conditions, such controlled manipulations are not feasible or entirely desirable. Rather, we relied upon established task performance standards and conditions, subject matter expert (SME) expertise, and readily available training resources to investigate the potential impact of BF techniques on Soldier performance.

Method

Selection of Soldier Population

The selection of One Station Unit Training (OSUT) Infantry Soldiers at Fort Benning, GA, was driven by two pragmatic considerations. First, to minimize potential confounding, the desired participants would consist of naïve personnel, with little or no prior knowledge or experience with the tasks to be trained. OSUT Soldiers are new to the Army and thus most likely to meet this criterion. Second, the Army Research Institute authors of this paper are based at Fort Benning and therefore minimized travel costs.

Selection of Tasks

Task selection was a three-stage process. First, a task had to have at least four steps, and there had to be an objective way of assessing task performance to verify proper task completion (a ‘Go’). Second, each task was rated by SMEs on a three-point scale along ten (10) criteria

dimensions (see Appendix A). Several of the criteria were based on traits inherent to the tasks themselves. For example, the task steps had to be carried out in a specific sequence, the task steps had to be clearly defined, and performance on the task steps had to be readily observable.[2]

Some of the criteria were based on more pragmatic grounds—for example, tasks on which many or most Soldiers at Fort Benning were well trained would make finding naïve participants difficult. Finally, at least two of the criteria were concerned with what one might call 'robustness'. That is, given the interest in examining BF in concurrent training, tasks that could be trained in a wide variety of locations would rate highly, as would tasks for which training aids could be easily generated. Any task that received a 'zero' on any of those criteria was removed from the task pool. Third, iterative discussions between the SMEs and the Government—based upon the numerical ratings and implementation considerations—whittled down the task pool from thirty-six (36) potential tasks to five (5) final tasks, as seen in Table 1 below. Once the final tasks were selected, estimates of the time required to train and test the tasks were established via mock data runs. (See Appendix B for time estimates.)

Table 1
Finalized Task List

Task Domain	Task Name
Knot Tying	Hand Cuff Rappel
First Aid	Fracture Bleed
Map Reading*	Resection

*Note. Only one (1) task (Resection) from the Map Reading domain was used.

Description of Tasks and Training Support Materials

Table 1 identified the four hands-on tasks and one cognitive task (Resection). Here we provide a brief description of the tasks and then discuss how the tasks are often trained (as contrasted with how the tasks were trained in these experiments). One point to bear in mind is that all of the hands-on tasks involved 'field expedient' methods. For example, the knot-tying and medical tasks used sticks, rags, and lengths of rope; there were no pre-manufactured materials used.

Hand Cuff. There are 10 steps in this task. To complete this task, the learner must manipulate a short length of rope (e.g., grasping the rope in the middle, looping over and under specific lengths, and tying two half-hitch knots) to tie an enemy combatant's wrists tightly enough so that they cannot escape. In contrast to Soldiers training in pairs (one Soldier providing the wrists, the other Soldier tying the rope), two empty soup cans were attached side-

[2] This raises an interesting distinction between the hands-on tasks used in this project and the cognitive tasks which are typical of the BF literature. While performance of a step in a cognitive task can be inferred from the output of an individual (e.g., an answer supplied to a math problem), that performance cannot be directly observed. Such is not the case with the hands-on tasks used here.

by-side to a small board and provided to each Soldier. Thus each Soldier could fully participate in all learning trials using materials easily available to most units.

Rappel. There are 19 steps in this task. To complete this task, the learner must find the middle length of rope, correctly place and route the rope around the wrists, legs and loins, correctly construct knots, and have enough rope left over after passing the rope around the waist and under the thighs to allow for a secure knot. If properly tied, the rope forms a harness around the body which supports rappelling. Each Soldier tied the rope around his own body so no other materials were needed.

Fracture. There are 10 steps in this task**.** To complete this task, the learner must select field expedient splint material (e.g., sticks or short sections of small-diameter plastic pipe) that reach to a joint above and below the fracture point, apply padding (e.g., rags from torn clothing), constructing the right kind of knot with the appropriate level of tightness, checking blood circulation, and checking for shock (assessed by a leading question from the instructors). Proper completion immobilizes the fracture so an injured person can be moved without causing more damage. In order to allow each Soldier to fully participate in training and to minimize safety concerns, simulated arms were produced from sticks and old clothing rather than having Soldiers work in pairs.

Bleed. There are 13 steps in this task. To complete this task, the learner must uncover the wound, apply a series of field dressings in a specific sequence, appropriately place dressings and knots, and ensure the wound is securely and appropriately covered. The same simulated arms from the Fracture task were used for this task.

Resection. There are 17 steps in this task. To complete this task, the learner must correctly identify the map declination angle, convert magnetic to grid azimuths, ensure accurate placement and alignment of the protractor on the map, know how to read angles on the protractor, and be able to distinguish where map lines intersect. Applying this process properly allows the learner to determine his location on a map, from knowing the grid azimuth to known positions. Each Soldier was provided a standard Army map sheet with selected locations circled and a small plastic protractor.

How and Where the Tasks Were Trained

Training for all tasks was conducted in a small group setting comprising 5-7 Soldiers. The same instructor conducted all training sessions. For each training session, there were 1-2 assistant trainers who observed Soldiers, corrected errors, and provided assistance, as needed. Testing was conducted immediately following the training session. All testing was conducted individually, with one trainer observing one Soldier as he performed the task. Separate holding areas were designated for Soldiers who had completed testing and for those waiting to be tested. The testing site was structured so Soldiers were spaced and oriented to ensure privacy and that the Soldier being tested could not receive help from fellow Soldiers. Each training/testing

session required approximately one hour to complete. Training/testing sessions were conducted in a variety of garrison and field conditions. This included open space under a covered area in garrison, at rifle firing ranges, and in other field training sites that were convenient for the supporting training units. The general sequence of events for a session is displayed in Table 2.

Table 2
Sequence of Events for Training/Testing Sessions

Brief	• Complete consent forms; check roster numbers and prior experience. • Brief training event/project to Soldiers.
Train	• Train each Soldier in a group setting on the specified task. • Remove one preceding step (or block) and re-train for total of 4 learning trials.
Test	• Read scenario; evaluate Soldiers individually and record results. • Prepare training aids for next group. • Repeat process for 5 groups per task/method.

The method in which the tasks were trained in Experiments 1 and 2 is not the way in which they are typically trained. The goal of these experiments was to (a) see if SME judgments of task complexity predicted performance differences and (b) if different types of BF affected performance in predictable ways. If the performance differed in the predicted ways, then the results could be used to provide trainers with some guidance on when to implement BF in comparable (i.e., concurrent) training conditions. In any case, comparisons between the traditional and BF methods of training would be comparing apples to oranges as the BF approach requires smaller instructor-to-student ratios, more repetitions, and better access to training aids. So any improved performance might be attributed to those factors rather than the BF method per se. (For a brief discussion of how the tasks used in Experiments 1 and 2 are typically trained, see Appendix C.) Again, the purposes of this research were to see (1) if BF is a feasible training approach in concurrent training settings, (2) what kind of tasks might benefit more from BF than others, and (3) different ways in which BF might be implemented. The first purpose is a more general one: namely, were Soldiers largely successful when BF is used? The second purpose is addressed in Experiment 1 and the third purpose in Experiment 2.

Participants

Two hundred and fifteen (N = 215) OSUT Soldiers from a single company of the 198th Infantry Brigade at Fort Benning, GA participated. One hundred and twenty (n = 120) of the Soldiers participated in Experiment 1 and ninety-five (n = 95) Soldiers participated in Experiment 2. Of these Soldiers, fifty-seven (n = 57) were E1s, seventy-eight (n = 78) E2s, and the remaining eighty (n = 80) were E3s. All participants were male. The different sample sizes in the two experiments were dictated by training schedules and other factors affecting Soldier availability. We did not collect any further demographic information barring a brief question regarding task-specific experience and/or training.

Design

Before proceeding to a more detailed discussion of the individual experiments, some general comments are in order. There were two experiments, each a 2 x 2 design. In Experiment 1, the variables were task type (Knots, First Aid) and task complexity (number of task steps). Recall that task complexity was based upon SME judgment regarding features of existing Army tasks, including number of steps, the extent to which one task step cued the performance of a later step, and so forth. As noted above, task complexity was not something that could be easily increased (i.e., adding task steps for the sole reason of increasing complexity). In Experiment 2, the variables were task type (Cognitive [Resection] vs. Hands-On [Knots]) and type of BF (Step vs. Block). A 'Step' BF is a very gradual removal of scaffolding across trials, as displayed in Figure 1. A 'Block' BF is a more accelerated removal of scaffolding, so that the shift from instructor to learner performance occurs more rapidly in a given number of learning trials.

In each experiment, we gathered eight pieces of performance information: (1) we assessed if the Soldier received a 'Go' on the task; (2) we noted the number of unattempted steps by the Soldier (a measure of task completion); (3) we recorded the total number of errors committed by a Soldier; (4) we recorded the total time (in seconds) it took to complete the task; (5) we recorded the first task step on which an error (if any) was made (this was done to see if there were any task steps that were particularly difficult); and (6) we measured the number of attempts made by a Soldier, where an attempt is operationalized as starting or 'restarting' a task. For example, every Soldier who completes the task has made at least one attempt. If a Soldier realizes he made a mistake and backtracks to correct the error that 'backtrack' counts as a second attempt. (This 'backtrack' can be either partial or total—a Soldier may back up just one step or start from scratch.) After four attempts, a Soldier was stopped and his performance was recorded as final, either "Go" or "No Go". If the Soldier received a "No Go" he was coached to successful task completion. We also attempted to classify any corrections made by a Soldier as either (7) proper corrections or (8) overcorrections. A proper correction is made when a Soldier backtracks no further than required to correct a given error. An overcorrection occurs when the Soldier backtracks too far—e.g., the Soldier makes a mistake on the next to last step and starts from scratch, when all that was necessary was to backtrack only one or a few steps.

Put more simply, we wanted information about the following 8 performance metrics:

1. If Soldiers were Go/No Go.
2. How many steps were unattempted.
3. Total number of errors.
4. How long (in seconds) it took to complete the task
5. Step on which first error occurred.
6. Number of attempts made to complete task.
7. How many proper corrections were made.
8. How many overcorrections were made.

We made specific predictions, derived from the role WM is thought to play in task learning, concerning the first four metrics. In brief, tasks that impose a high WM load should be performed more poorly than tasks that impose a low WM load. Consider Table 3 below. Table 3 indicates that low working memory load tasks should, vice high working memory load tasks, exhibit higher Go rates, fewer unattempted steps, fewer errors, and take less time to complete at testing. In Experiment 1, we operationally define working memory load in terms of task complexity (or number of task steps), and, in Experiment 2, in terms of how BF is conducted. So the overall pattern of predictions in both experiments corresponds very closely to that shown in Table 3.

Table 3
Working Memory (WM) Load and Performance

Go/No Go	Unattempted Steps	Errors	Time
LWML>HWML*	LWML<HWML	LWMHL<HWML	LWML<HWML

*Note. LWML=low working memory load, HWML=high working memory load.

The last four performance metrics listed above were treated as post-hoc comparisons only, as they either involved knowledge of how the task would be performed when trained via BF (i.e., on what task step the first errors would tend to occur) or involved self-monitoring behaviors on the part of the Soldier (i.e., proper and overcorrections).

Experiment 1. The experimental design is displayed in Table 4. Each cell is numbered to make clear how the hypotheses were tested. Number of task steps (the criterion of task complexity) is given in parentheses following the task name. All tasks in Experiment 1 were 'step' faded (i.e., gradually—as displayed in Figure 1).

Table 4
Design for Experiment 1 – Step Fade

Experiment 1 (Step Fade)		
	Task Type: Knot Tying	Task Type: First Aid
Task Complexity: Low	(1) Hand Cuff (10 steps)	(3) Fracture (10 steps)
Task Complexity: High	(2) Rappel (19 steps)	(4) Bleed (13 steps)

Now we can make explicit the links between Tables 3 and 4. Because the Knot Tying (Hand Cuff) task is arguably less complex (i.e., has fewer task steps) than the Knot Tying (Rappel) task, the former should impose a lower working memory load than the latter. The same should hold true of the First Aid (Fracture) as compared to the First Aid (Bleed) tasks. So the low complexity tasks should exhibit higher 'Go' rates, fewer unattempted steps, fewer errors, and a faster completion time than the high complexity tasks.

Discussing this procedure also highlights another possible distinction between cognitive and hands-on tasks. When a worked example (e.g., math or computer programming problem) is presented to a learner, the assumption is that the learner is mentally processing ('performing') the steps presented in the worked example. In these experiments, some level of participation was assured in that an instructor modeled the behavior and had the learners mimic their behavior to the best of their ability. There is also the additional information available to the learner of visual feedback, which is not present in the cognitive tasks so often used in the research literature.

As judgments of task complexity were based on only one main factor (task steps) and rooted in SME assessment, it did not seem prudent to make predictions across task types. In other words, while we were fairly confident that (1) was less complex than (2), we were not confident in saying that (1) was less complex than (4). Thus all hypotheses were tested within task type (this procedure was also applied in Experiment 2). The predictions for Experiment 1 are displayed in Table 5.

Table 5
Predictions for Experiment 1

Experiment 1		
Variable	Task Type: Knot Tying	Task Type: First Aid
'Go'/'No Go'	Hand Cuff > Rappel	Fracture > Bleed
Steps Not Attempted	Hand Cuff < Rappel	Fracture < Bleed
Total Errors	Hand Cuff < Rappel	Fracture < Bleed
Total Time	Hand Cuff < Rappel	Fracture < Bleed

For purposes of simplicity, we stipulated that 'better performance' referred to a higher 'Go' rate, fewer unattempted steps, fewer errors, and less time to complete the task. To summarize Table 5, we expected that Hand Cuff performance would be better than Rappel performance and Fracture performance would be better than Bleed performance.

Experiment 2. The experimental design is displayed in Table 6. Each cell is numbered to clarify the order in which the hypotheses were tested. Whereas all tasks in Experiment 1 were gradually ('step') backwards faded, half of the tasks in Experiment 2 were step faded and half were accelerated ('block') backwards faded.

Table 6
Design for Experiment 2

Experiment 2 (Step vs. Block Fade)		
	Task Type: Map Reading	Task Type: Knot Tying
Fading Type: Step	(5) Resection	(7) Rappel[3]
Fading Type: Block	(6) Resection	(8) Rappel

[3]The Rappel 'step' fade data is the Rappel data from Experiment 1. As all of the tasks in Experiment 1 were step faded, this reuse of the data seems warranted. In addition, replicating that condition would have raised the overall *N* of Soldiers needed for this research and hence required coordinating with two OSUT companies rather than just one.

Because the same tasks were used twice (the Resection was faded two different ways, and the Rappel task was faded two different ways), task step was not a critical variable in this experiment. Rather, the crucial variable is how BF occurred. WM load should be higher in the block fade than the step fade condition. Understanding why this is so requires a more detailed discussion of step vs. block fading. The distinction between step and block fading can be roughly understood, to a first approximation, as a gradual (step) vice accelerated (block) transition between performing a task with instructor assistance to performing the task without instructor assistance. This distinction is shown in Figures 2 through 5 below.

In Figure 2, the number of steps that the Soldier must perform without instructor assistance (indicated by the gray portion of the bars) increases relatively slowly across learning trials. In Figure 3, the number of 'unassisted' steps increases more rapidly across learning trials. The same holds true when comparing Figures 4 and 5. To put it in Army training terms, tasks that proceed more rapidly from 'crawl' to 'walk' are intuitively more difficult to perform than tasks that proceed more slowly from 'crawl' to 'walk'.

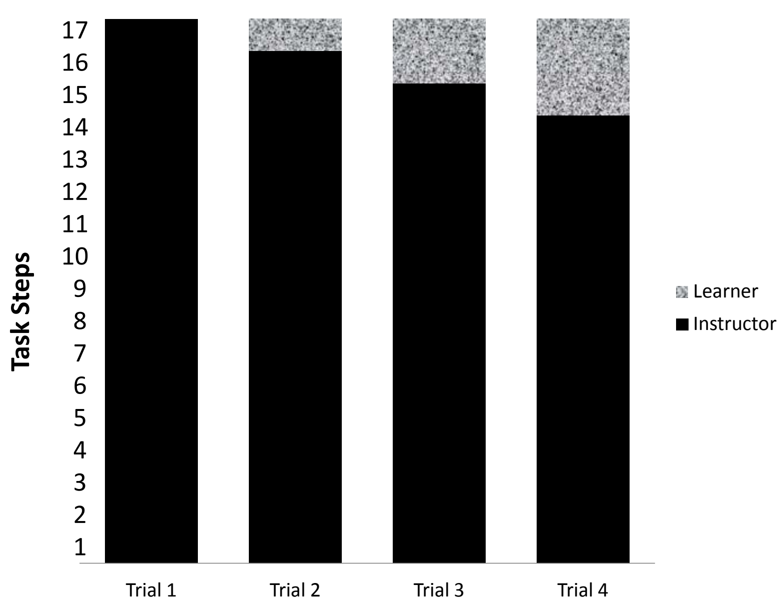

***Figure 2*. Step fading Map Reading Resection task in Experiment 2.**

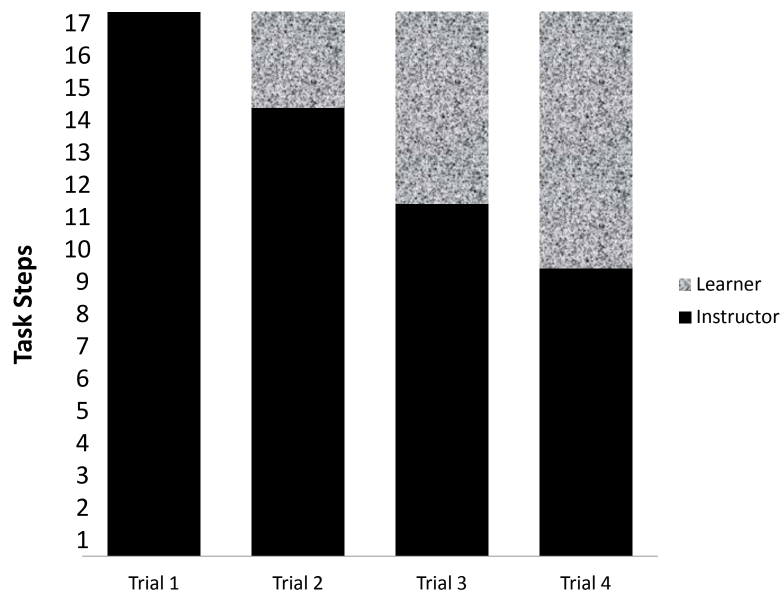

***Figure 3*. Block fading Map Reading Resection task in Experiment 2.**

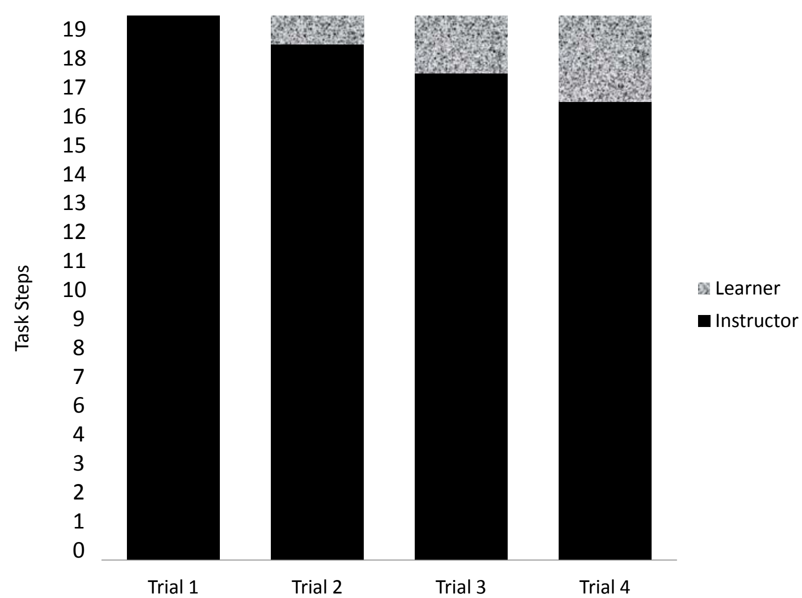

***Figure 4*. Step fading Knot Tying Rappel task in Experiment 2.**

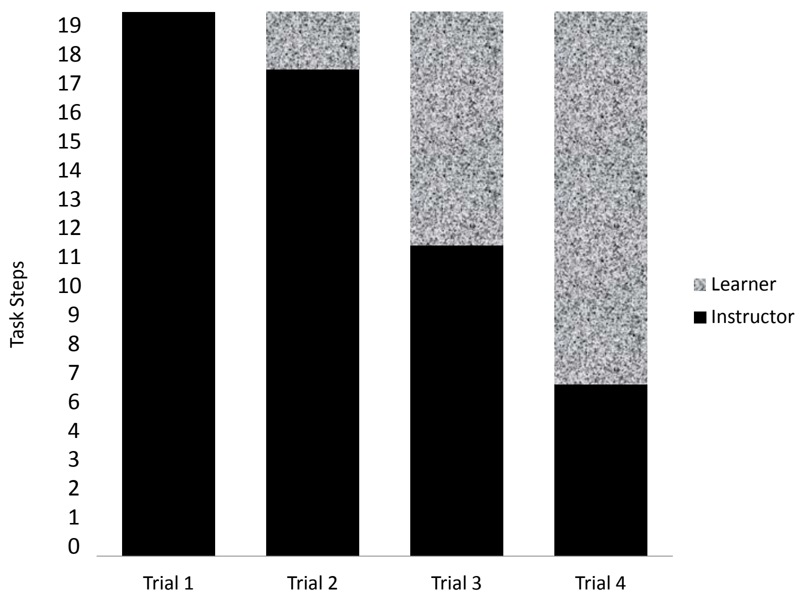

Figure 5. **Block fading Knot Tying Rappel task in Experiment 2.**

Given the prior discussion, our theoretical interpretation of the difficulty imposed by more rapidly increasing (block fading) the transition from ‘crawl’ to ‘walk’ is that of working memory load. Our pattern of predictions follows those as shown above in Tables 3 and 5. In other words, step faded tasks should exhibit better performance (stipulated to mean higher Go rates, fewer unattempted steps, fewer errors, and less time to complete) than block faded tasks (see Table 7).

Table 7
Predictions for Experiment 2

Experiment 2		
Variable	Map Reading Resection Task	Knot Tying Rappel Task
‘Go’/’No Go’	Step > Block	Step > Block
Steps Not Attempted	Step < Block	Step < Block
Total Errors	Step < Block	Step < Block
Total Time	Step < Block	Step < Block

Procedure

The point of examining BF training in Army contexts was to see how effective and efficient it would be with (a) hands-on tasks, not just the cognitive tasks addressed in the research literature, in (b) Army training settings (e.g., in garrison or on marksmanship ranges), and (c) with only a few learning trials. The latter point is important, as one of the tasks used had 19 steps. This would require a quite lengthy interaction between an instructor and one or more learners and would make the training approach unwieldy if more steps were faded, one step at a

time. Therefore, it was decided that there would be only four total learning trials per task before individuals were tested. It is also worth repeating a point made earlier: we were not interested in comparing the effectiveness of BF training to how these tasks are typically trained. Rather, positive results (good performance) here would indicate that BF is a feasible way to train multi-step tasks in concurrent training stations that are usually conducted with small groups in short periods of time at disparate training locations. If performance differences were as predicted (more task steps led to poorer performance, and step fade performance was better than block performance), then some rough heuristics would be in place that could aid a trainer in deciding which tasks to BF.

Soldiers were trained in groups of five to seven at a time on one of the five tasks. Soldiers were asked if they had any training or experience relevant to the task at hand, and if they answered 'yes', they were asked to briefly describe that training. The instructor then demonstrated the task from beginning to end (i.e., like a worked example) and the Soldiers watched. Then the first learning trial began as a guided demonstration. In other words, each Soldier watched and mimicked the task steps performed by the instructor. As shown in Figure 1, there were no 'learner only' steps. In the second trial, the instructor and the learner performed the first task steps and the Soldier(s) performed the last task steps by himself (Note: the number of steps performed by the instructor and the number of steps performed by the Soldier was determined by the specific experimental condition). In the third and the fourth learning trials, each Soldier was performing more and more of the later task steps, and, thus, the instructor was performing fewer and fewer of the earlier task steps. After the fourth learning trial was completed, Soldier ability to perform the task without any instructor help was measured. Soldiers were assessed separately from the group so that they would not be able to observe or be observed by other Soldiers who were being assessed. Soldier performance was assessed by instructors via checklists, with spaces for noting all eight (8) of the performance criteria discussed above (see Appendices C and D for the performance checklists).

Analysis Strategy

All analyses were conducted using the Statistical Package for the Social Sciences (SPSS) for Windows, and the alpha level for significance was set at .05 (two-tailed) for all tests. As this is an initial test of the hypotheses in question, all *p* values should be treated with caution. Any confidence in the strength or pattern of the relationships should be tempered in the absence of replication. In analyzing the data, we used the following four-stage strategy. First, we examined the extent to which the prior knowledge question could be used as a covariate. Second, we visually scanned the overall pattern of variables to see if the data posed any problems for statistical analysis. Third, we statistically analyzed all of the eight outcome variables in both experiments (see above for listing of the eight variables). Fourth, we conducted a post-hoc analysis which allowed us to draw a 'big picture' from both experiments. The post-hoc analysis assessed how reliably the data trend corresponded to that predicted and the strength and direction of the relationship between number of task steps and performance variables. We were especially interested in the latter because the task steps were the primary determinant of task complexity and because this is the kind of observable metric which might undergird instructor intuitions regarding the value (or lack of value) for BF.

Results

Before turning to a detailed discussion of Experiments 1 and 2, we screened all of the data for issues associated with prior knowledge and other problems that might have interfered with statistical analysis. Our primary concern with the prior knowledge question regarded whether or not it possessed enough variability to serve as a covariate (whether formal or informal). The primary concern with the visual screening of the data involved avoiding potential problems with later statistical analyses.

Prior Knowledge

The results of the prior knowledge question are displayed in Table 8. Most individuals indicated prior training or experience with knots, and a few indicated prior training or experience with the first aid and map tasks. Unfortunately, the pattern prevented using the prior knowledge results as a covariate. For example, in any two task conditions which entered into a comparison, the prior knowledge question was predominantly yes (or no) in both conditions.

Table 8
Prior Knowledge by Task

Prior Knowledge	Tasks						
	Hand Cuff	Rappel	Fracture	Bleed	Step Fade Resection	Block Fade Resection	Block Fade Rappel
No	1	1	28	28	25	26	0
Yes	29	29	2	2	7	7	30

Visual Screening

In scanning the data in both experiments by task, it became apparent that we could simplify the data set by reducing all of the frequency variables (attempts, unattempted steps, proper corrections, overcorrections, and total errors) to bivariate ('0' and '1 or more') data with minimal loss of information. This also simplified the data analysis in another way, namely that we could examine all of the simplified variables via the same procedure as 'Go/No Go'—namely, chi-square tests. This also allowed for more of an 'apples to apples' comparison, as the more complex tasks, by definition, are constituted of more steps. Time was examined via independent sample *t*-tests, and 'step on which first error occurred' was used descriptively only. (See Appendix E for all descriptive statistics.) During the screening process we also examined the variables to be examined post-hoc (i.e., step on which first error occurred, number of attempts made to complete task, how many proper corrections were made, and how many overcorrections were made). In at least two cases no comparisons would have been possible because the pattern in the conditions being compared was exactly the same. Subsequent conduction of the post-hoc analyses revealed that none of them were statistically significant, and so for purposes of simplicity we will not refer to those four variables again. (See Appendices F and G.)

Experiment 1. In Table 9, we repeat the hypotheses for Experiment 1 and the significance level of the corresponding statistical test (chi-square for the first three variables in the table, independent sample *t*-test for time). Only one out of the eight comparisons reached statistical significance. Namely, there were more errors committed in the Knot Tying (rappel) task than in the Knot Tying (handcuff) task.

Table 9
Hypothesis Tests in Experiment 1

Variable	Task Type: Knot Tying	*P* Value	Task Type: First Aid	*P* Value
'Go'/'No Go'	Hand Cuff > Rappel	.30	Fracture > Bleed	.10
Steps Not Attempted	Hand Cuff < Rappel	.31	Fracture < Bleed	N/A**
Total Errors	Hand Cuff < Rappel	.05*	Fracture < Bleed	.10
Total Time	Hand Cuff < Rappel	.07	Fracture < Bleed	.53

*Statistically significant.
**No unattempted steps in either condition.

Experiment 2. In Table 10, we repeat the hypotheses for Experiment 2 and the significance level of the corresponding statistical test (chi-square for the first three variables in the table, independent sample *t*-test for time). None of the eight (8) statistical comparisons were significant.

Table 10
Hypothesis Tests in Experiment 2

Variable	Map Reading Resection Task	*P* Value	Knot Tying Rappel Task	*P* Value
'Go'/'No Go'	Step > Block	.85	Step > Block	.17
Steps Not Attempted	Step < Block	.29	Step < Block	.55
Total Errors	Step < Block	.29	Step < Block	.79
Total Time	Step < Block	.59	Step < Block	.45

The Big Picture

Within the limits of the data, it appears that judgments of task complexity based solely on number of task steps are not a very accurate guide for performance prediction. There is, however, another way of looking at the data that is relevant. Even though there were few statistically significant results among the individual comparisons, we can still ask the following question: is there a consistent trend in the hypothesized direction? We answer that question in

Tables 11 and 12. Both tables contain columns labeled ‘direction’. This column indicates if the absolute values given (not the statistical significance of the difference between those values) are consistent with the predictions made.

Table 11
Trend Data from Experiment 1

Experiment 1				
Variable	**Task Type: Knot Tying**	**Direction Confirmed?**	**Task Type: First Aid**	**Direction Confirmed?**
‘Go’/’No Go’	Hand Cuff > Rappel	Yes	Fracture > Bleed	Yes
Steps Not Attempted	Hand Cuff < Rappel	Yes	Fracture < Bleed	No
Total Errors	Hand Cuff < Rappel	Yes	Fracture < Bleed	Yes
Total Time	Hand Cuff < Rappel	Yes	Fracture < Bleed	Yes

Table 12
Trend Data from Experiment 2

Experiment 2				
Variable	**Map Reading Resection Task**	**Direction Confirmed?**	**Knot Tying Rappel Task**	**Direction Confirmed?**
‘Go’/’No Go’	Step > Block	Yes	Step > Block	Yes
Steps Not Attempted	Step < Block	No	Step < Block	Yes
Total Errors	Step < Block	Yes	Step < Block	No
Total Time	Step < Block	No	Step < Block	Yes

We assessed the reliability of the directional differences via sign tests, which essentially calculate the likelihood of getting a given number of directional differences (e.g., Condition A being higher than Condition B, 7 out of 8 times) if drawn from a population in which Conditions A was higher than Condition B half the time, and half the time the reverse were true. In Experiment 1, 7 out of the 8 comparisons were in the hypothesized direction but not significantly so (sign test $p = .07$). In Experiment 2, only 5 out of the 8 comparisons were in the hypothesized direction (sign test $p = .73$). Based on the sign tests, there is some reason to place more faith in the impact of task steps upon performance than type of fading (block versus step).

Discussion

A restatement of the three purposes behind this research is now appropriate, and will guide the rest of this section. The first purpose was to address the feasibility of BF in concurrent training settings, the second was to assess what kinds of tasks might benefit more from BF than others, and the third was to assess different ways in which BF might be implemented.

Given the relatively high Go rates achieved across all tasks (ranging from 77% to 99%), it appears that BF is a feasible approach to training in concurrent settings. This conclusion is bolstered by noting that the training aids used were low tech and easy to construct. Anecdotal evidence also indicates that Soldier motivation and interest was high. Achieving such a 'Go' level within an hour's time indicates that BF is also relatively efficient and can aid in speeding task learning.

The second purpose—assessing what kinds of tasks might benefit <u>more</u> from BF—was a more difficult challenge. It seemed plausible that the number of task steps would be a reasonable predictor of task performance. As noted in the prior section, there was only slight evidence for this. There are several reasons why the evidence that emerged was only slightly in favor of using task steps as a predictor. First, in the academic research literature, it is sometimes possible to construct an artificial task that is designed to vary in complexity for the sake of showing theoretical relationships. This was not feasible in the current research for the simple reason that we wanted our results to have direct application to Army tasks and settings. This meant that we had to select from existing Army tasks, and thus did not have the luxury of 'custom fitting' tasks to our hypotheses. The second reason is that, when using newly created, theoretically derived tasks, it may be possible to specify very precisely how such tasks vary in ways related to WM load. When judging existing Army tasks, we had to rely on SME judgments related to WM load. The third reason involves differences between hands-on and cognitive tasks. In the academic literature, when a worked example (of, say, a math problem) is presented to a learner, it is <u>assumed</u> that the learner is actively engaged in the task. But the kind of learning that takes place with hands-on tasks seems quite distinct. Consider how the hands-on tasks were trained in this research. On the first learning trial, not only did the instructor demonstrate how each task step was completed, but the Soldiers also mimicked the instructor's behavior while receiving feedback. That is, explicit modeling (on the part of the Soldier), diagnosis, and repair (on the part of the instructor) took place. This may result in a much higher level of scaffolding than is typical of cognitive tasks. The fourth reason is relatively straightforward: perhaps the 'highly complex' tasks we chose simply weren't complex enough. It should be pointed out that we were balancing two factors that were somewhat at odds with one another. On the one hand, we wanted tasks that were simple enough to be trained in one concurrent training setting. On the other hand, we wanted tasks that varied enough in complexity so that some would exhibit notably better performance than others. In other words, it is possible that none of the tasks imposed enough of a WM load to result in the significantly poorer performance we expected to see in certain conditions.

The third purpose—assessing different ways in which BF might be implemented—was also a difficult challenge. As noted above, one of the possible reasons that the predictions of Experiment 1 were not well supported was that the ‘high complexity’ tasks were not complex enough. This is also a possible reason for the pattern of results seen in Experiment 2. If the tasks were relatively simple, perhaps block fading the tasks made them only slightly more complex rather than (as we had hoped) ramping up the working memory load on a task that was already significantly taxing.

Recommendations

If there are a set of tasks that instructors feel Soldiers would benefit from learning, and these tasks are serial in nature (they must be completed in a specific sequence), constructing training materials for them is easy (takes little time and involves easy-to-find materials—i.e., like rope!). If training can be conducted with little reliance on technology, then BF is likely a suitable method for training in concurrent settings. BF has the advantages of being relatively straightforward to administer, mapping well onto the ‘crawl-walk-run’ philosophy of Army training, and explicitly shifting the focus onto the learner. The latter ‘learner-centric’ aspect of BF dovetails well with the tenets of the Army Learning Model (ALM).

However, much more needs to be understood to provide concrete guidance on how to judge among tasks that meet the above criteria. Assume, for example, that there are two tasks that are roughly equivalent (in the SME’s judgment) along the above criteria. What other factors should be weighed? There are likely things about the tasks that experienced Drill Sergeants (DS) or instructors would know that could guide their decisions. For example, in their experience as a DS, which tasks have proven especially difficult for Soldiers to learn? In a similar vein, is it the entire task that is difficult (and hence might benefit from training via BF) or just one specific portion of the task? Are there specific tasks that, in the estimation of the DS, are forgotten more rapidly than others (whether due to task complexity or infrequency of opportunity to retrain)? Such tasks might also benefit from BF, although verifying this would require a more longitudinal design than the ‘one shot’ research methodology used here.

In sum, BF holds promise for use in concurrent training settings where small groups and low Soldier-to-Instructor ratios might be expected. What is still needed, however, is a clearer set of criteria that can guide instructors in deciding which tasks would benefit from BF and which would not. Subsequent research on BF should focus, in part, on how to incorporate DS knowledge of tasks in the decision to use BF techniques during training.

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Acronyms

ALM	Army Learning Model
BF	Backwards Fading
CLT	Cognitive Load Theory
DS	Drill Sergeants
IET	Initial Entry Training
OSUT	One Station Unit Training
SME	Subject Matter Expert
WM	Working Memory

Appendix A

Task Selection Criteria

Criterion 1:	Training location: defines how easy it will be to train the task. Tasks that can be trained at any location (classroom, field, hallway, etc.) will rate high. Tasks requiring more specific, specialized, or protected facilities or accommodation will receive a lower rating.		
Scale:	1=Specialized accommodation (i.e., classroom w/desks & chairs, surveyed location, wooded area)	2=Limited but common (i.e., indoors, open field, covered area)	3=Any location
Criterion 2:	Training Aids and Resources – Most tasks will require equipment, materials, or training aids. This criterion indicates the level of anticipated difficulty of developing or obtaining equipment, materials, or training aids. Those tasks that require no materials or for which materials will be easy to obtain or create will be rated high. Those tasks which require specialized equipment or for which support materials are more difficult to obtain or acquire will rate lower.		
Scale:	1=Hard to obtain	2=Limited	3=None required or simple/easy to obtain
Criterion 3:	Fruitfulness – With a goal of this research being to develop techniques and materials of immediate or near-term value to MCoE courses and trainers, this criterion will rate those factors. Tasks trained in or very similar to tasks trained in multiple courses and/or to large (> 1, 000 per FY) student populations at the MCoE will rate high. Those similar to a limited number of tasks trained in BCT/OSUT, professional development, or functional courses and/or impacting a smaller (< 250 per FY) population of students at the MCoE will rate lower. (NOTE: Training motivation and relevance of the task to future duties, professional development, and/or general or professional knowledge will be a consideration under this criterion.)		
Scale:	1=Applicable to a few courses and students (<250 per FY)	2=Applicable to some courses/fewer (1,000 to 250 students per FY) students	3=Applicable/similar to many MCOE courses and/or large (>1,000 per FY) student populations
Criterion 4:	Distinct Steps – Tasks with well defined procedures and steps will be rated high for this criterion. Tasks with steps and procedures that are less defined and structured will be rated lower.		
Scale:	1=80-89% of the steps defined and distinct	2=90-99% of the steps defined and distinct	3=All steps defined and distinct

Task Selection Criteria *(continued)*

Criterion 5:	Defined Sequence – Tasks with steps and procedures that have a singular or defined sequence will be rated high. Tasks with steps and procedures that can be done in a less defined order will rate lower.		
Scale:	1=60-79% of steps	2=80-89% of steps	3=>90% of steps
Criterion 6:	Time to Train – SMEs or trainer will be consulted to determine the estimated time required to train the task. Training time will be assessed/estimated for a single iteration of training. Tasks requiring less than 5 minutes for a single training iteration will receive a high rating. Tasks requiring 5 minutes or more to train will be rated lower. (NOTE: Consideration will be given to highly-complex tasks to adjust their ranking in this criterion. Highly-complex tasks are expected to take relatively longer to train.)		
Scale:	1=9-10 minutes to train	2=5 to 8 minutes to train	3=Can be trained in less than 5 minutes
Criterion 7:	See Performance/Collect Data – The ability to see/observe task performance is essential for data collection, training assessment, and determination of successful performance. Tasks with more than 90% of the steps and procedures readily observable will rate high. Those tasks with steps and procedures that are less visible will rate lower.		
Scale:	1=70-79% steps are easily visible	2=80-89% steps are easily visible	3=>90% steps easily visible during performance
Criterion 8:	Skill Dependency – Many military tasks are interrelated or dependent on other tasks and skills. This criterion assesses task dependency on proficiency in other tasks and skills. The task rates high if no other skills are required for correct task performance. The greater the dependency, the lower the rating.		
Scale:	1=More than 2 related skills are required	2=Not more than 2 related skills are required	3=No other skills are required for success
Criterion 9:	Obscurity – Finding populations of naïve participants will be key to conducting experiments and determining statistically significant results and findings. This criterion will rate tasks high that would not be familiar to the expected participants. Tasks familiar to greater numbers of the expected participants will be rated low. (NOTE: Rank, time in service, and expected experience of potential training audiences will be considered in this criterion.)		
Scale:	1=30% of personnel are expected to be familiar with the task or skill	2=20% of personnel are expected to be familiar with the task or skill	3=<10% of personnel would be expected to be familiar with the task or skill

Task Selection Criteria *(continued)*

Criterion 10:	Access to Training Content – The ability to determine task steps and procedures, develop and refine training materials, and assure doctrinal correctness of performance criteria is essential for the tasks selected for experimentation. This criterion will rate tasks with readily available subject matter experts and existing training materials higher than those with only doctrinal references available.		
Scale:	1=Only doctrinal references available	2=Approved training materials available	3=SME(s) available

Appendix B

Training Time Estimates

Domain	Task	Condition	Estimated Training Time (minutes)		Iterations	Estimated Total Time to Train	Estimated Assessment Time (minutes)		Estimated Total Time per Small Group (minutes)
			Demonstration (includes limited refresh of prerequisite skills)	Guided Demonstration			Individual Soldier	Group (3 w/ 2 trainers)	
Knot Tying	Tie a Hand Cuff knot	Step Fading	3	4	3	15	2	4	19
	Tie a Rappel seat	Step Fading	4	4	5	24	4	12	36
		Block Fading			3	16	4	12	28
First Aid (field expedient materials)	Immobilize a suspected Fractured arm	Step Fading	8	6	3	26	6	18	44
	Control Bleeding in an extremity (arm)	Step Fading	10	6	5	40	6	18	58
		Block Fading			3	28	6	18	46
Map Reading	Determine a map location by Resection	Block Fading	8	6	3	26	6	18	44

Appendix C

How the Tasks Are Typically Trained

There are numerous approved programs of instruction (POIs) being implemented for different Army courses. Multiple POIs each train similar tasks, such as medical skills, knot tying, and map reading. While some tasks are similar, and at times even have the same approved Task Number, there is very seldom an Army-approved method or process for training each task. Therefore, there is no single method that is used to train most tasks. In addition, responsibility for training tasks differs. Some tasks are trained by the course cadre, some are trained by subject matter experts from outside the cadre, and others might be trained by the unit leaders. Given this flexibility in how tasks could be trained, there are some general commonalities of training for certain types of tasks and within selected POIs, and for selected target audience students. The following information provides a general description of how each of the tasks for the backwards fading project are most likely trained for selected Army personnel. Undoubtedly, given the flexibility available to implement POIs, some courses could vary from the following method of training the tasks.

Medical Tasks. During Initial Entry Training (IET) Soldiers receive training on various medical tasks, to include controlling bleeding and treating a suspected fracture. Some IET courses present the training using the current techniques available to Soldiers deployed in a combat zone (e.g., combat application tourniquet (CAT), inflatable plastic splint) while other courses train the more traditional techniques contained in the Soldier's Manual of Common Tasks (e.g., first aid bandages, sticks). Another variation of note is the trainer for the tasks. In some IET courses, the trainer might be a qualified Army medic while in others the trainer is the Drill Sergeant. Regardless of the techniques trained and the trainer, the training procedure is generally consistent between IET courses.

Training is usually conducted in a classroom setting. The number of students could be a platoon-size unit (about 30-50 students) or a company-size unit (about 100-200 students). There is usually a single trainer for the group, and one or more assistant trainers might be present for portions of the training. The primary trainer, usually located at the front of the class area, will use either PowerPoint slides or a live demonstration to explain the medical task. If PowerPoint slides are used for a company-size unit, there will likely be multiple screens in the classroom to enhance the viewing by students. The primary trainer will explain the task and talk through task execution, step-by-step. If the trainer is using a demonstration, the trainer will execute each step as it is explained. Following the talk through and/or demonstration to the large group, the trainer will answer student questions about the task. As a general rule, the initial training time for controlling bleeding will last about 30-45 minutes and the initial training time for treatment of a suspected fracture will last about 60-80 minutes.

When all questions have been answered, the students are organized into teams of 2-10 students per team. One student per team serves as the "injured Soldier" while the other students practice executing the task. Each student team will be provided a set of materials (e.g., bandages, CAT) needed to perform the task. The trainer will typically talk through the task while the students make their first attempt to execute the task. If assistant trainers are present,

they will circulate among the student teams to observe, answer questions, and assist, when necessary. Depending on the training schedule and other requirements, students could typically have about an hour to practice the task, with students changing positions from injured Soldier to the person performing the tasks. During this practical exercise period, Drill Sergeants observe Soldier performance, but there is typically not a formal or standard assessment of performance conducted. Even though all student team members will observe the practice exercises, it is possible that not all will have the opportunity to actually perform the task or be evaluated in task performance.

At one point in the recent past, TRADOC directed that all IET Soldiers complete Combat Lifesaver (CLS) training during IET. Completion of this training required that Soldiers be individually assessed on their ability to perform the various medical tasks, including controlling bleeding and treating a suspected fracture, among others. Units would arrange test stations and every Soldier would rotate between the test stations to be individually evaluated on performing the tasks, using the task standard contained in the CLS course guide. Testing all Soldiers could take an entire day, depending on the number of Soldiers in the unit and the number of available evaluators.

Map ReadingTask. While map reading tasks are trained in several Army courses, resection is usually not a typical task that is trained. It is not trained in Basic Combat Training (BCT), but is trained in some IET courses (e.g., 13F OSUT). Our review of some POIs did determine that resection is taught in the Warriors Leader Course (WLC). Training is usually conducted in a classroom setting. The number of students is usually a platoon-size unit (about 30-50 students). There is usually a single trainer for the group, and possibly one assistant trainer for portions of the training. The primary trainer, usually located at the front of the class area, will use PowerPoint slides to explain the resection task. The primary trainer will explain the task and talk through task execution, step-by-step. Following the talk through to the large group, the trainer will answer student questions about the task. As a general rule, the initial training time for resection will last about 60 minutes.

When all questions have been answered, each student team will be provided a set of materials (e.g., map, protractor) needed to perform the task. The trainer will typically talk through the task while the students make their first attempt to execute the task. If an assistant trainer is present, he will circulate among the students to observe, answer questions, and assist, when necessary. Depending on the training schedule and other requirements, students could typically have about an hour to observe or practice the task. During this practical exercise period, trainers observe Soldier performance, but there is typically not a formal or standard assessment of performance conducted. The WLC evaluation of the resection task is rolled into the land navigation practical test that students must complete. Students must successfully navigate over terrain to locate points on the ground, and could require the use of resection skills to plot the location of one or more points.

Knot TyingTasks. As with medical tasks, tying an assortment of knots is included in various Army courses. While some knots, such as rappel seat are trained in multiple courses, some knots are not trained in any course that we have been able to determine. As a case in point, the handcuff knot is not formally taught in any military course, to the best of our knowledge.

The rappel seat is trained during the Ranger and Air Assault courses as part of rappel training. Generally, one trainer will teach a group of about 50 students. The trainer will typically be in a central location where all students can see and observe the trainer actions (typically students are arranged in a large circle around the trainer). As the trainer executes the task step-by-step, he explains what he is doing and moves around the area so all students will be able to observe. Once the talk through with accompanying demonstration is complete, the trainer answers any questions. Following questions, each student will practice the task. Each student typically has his own section of rope and will tie the rappel seat around his body. The trainer will usually talk through the task, demonstrate each step, and observe the large group of students as they perform the task. Depending on available time, students could be allowed to tie the rappel seat multiple times. As the training period nears completion, the trainer will inspect each student to ensure the rappel seat is properly tied. The trainer will ensure that all knots are correct, properly positioned, and that the rappel seat is adequately tight enough to remain on the student's body.

Appendix D

Performance Checklists from Experiment 1

Hand Cuff Knot Assessment

1. Rank: ________ and MOS ___________
2. Have you received other knot tying training? (e.g., military, mountaineering, Scouting)? YES NO (if YES, explain)

____

____

____

Read test instructions. Note start time.

	Performance Steps	1st	2nd	3rd	4th
	1. Grasp the middle of the rope in both hands, palms down, about 12 inches apart.				
	2. Create a loop with the left hand by twisting the rope away from you so that the running end lies over the rope between your hands.				
	3. Create a loop with the right hand by twisting the rope toward you so that the running end lies under the rope between your hands.				
	4. Pass the left running end of the loop under the right running end of the right loop and over the right outside loop.				
	5. Pass the right running end of the loop over the left running end of the left loop and under the left outside loop.				
	6. Place the loops over the detainee's wrists.				
	7. Tighten both loops around wrists pulling the (left and right) standing ends of the rope.				
	8. With the left running end of the rope, tie two half hitches around the left wrist loop.				
	9. With the right running end of the rope, tie two half hitches around the right wrist loop.				
	10. Dress the knot.				

√ = step done correctly GO Yes No # Attempts _____ # Steps Not Attempted______ # Proper Corrections_____
X = step done incorrectly # Over Corrections_____ 1st Step Error______ Total Errors_______ Total Time _____

Rappel Seat Assessment

1. Rank: ________ and MOS __________
2. Have you received other knot tying training? (military, mountaineering, Scouting)? YES NO ; if YES, explain

____

____

____

Read test instructions. Note start time.

	Performance Steps	**1st**	**2nd**	**3rd**	**4th**
	1. Find the middle of the sling rope and make a bight.				
	2. Decide which hand will be used as the brake hand (strong side hand) and place the bight on the opposite hip.				
	3. Reach around behind and grab a single strand of rope (trailing free end). Bring it around the waist to the front and make two overhand twists/loops on the other strand of rope, thus creating a loop around the waist.				
	4. Pass the two ends between the legs, ensuring they do not cross.				
	5. On the backside of the body, pass 1 end (left or right) up under the loop around the waist, bisecting the back pocket flap on the trousers.				
	6. On the backside of the body, pass 1 end (left or right) up under the loop around the waist, bisecting the back pocket flap on the trousers.				
	7. Pull up on both ropes (while squatting slightly), tightening the seat.				
	8. Pass one rope end (left or right) through the leg loop from rear to front creating a half hitch on hip.				
	9. Pass one rope end (left or right) through the leg loop from rear to front creating a half hitch on hip.				
	10. Bring the longer of the two ends across the front to the non-brake hand hip.				
	11. Holding one working end in each hand, place the working end in the right hand over the one in the left hand. (Note: Steps 11-14 are tying the square knot.)				
	12. Pull it under and back over the top of the rope in the left hand.				
	13. Place the working end in the left hand over the one in the right hand				
	14. Pull it under and back over the top of the rope in the right hand.				
	15. Dress the knot down.				
	16. On one side (left or right) of the square knot, tie a half hitch knot.				
	17. On other side (left or right) of the square knot, tie a half hitch knot.				
	18. Ensure 4 inches of rope protrudes past each half-hitch.				
	19. Tuck any excess rope in the pocket below the square knot.				

√ = step done correctly GO Yes No # Attempts _____ # Steps Not Attempted______ # Proper Corrections_____
X = step done incorrectly # Over Corrections_____ 1st Step Error______ Total Errors_______ Total Time _____

Suspected Fracture Assessment

1. Rank: ________ and MOS __________
2. Besides IET, have you received other medical training? (military, civilian, Scouting)? YES NO; if YES, explain

____

____

____

Read test instructions. Note start time.

	Performance Steps	1st	2nd	3rd	4th
	1. Select splints that reach beyond the joints above and below the fracture.				
	2. Check blood circulation below the fracture before applying the splints.				
	3. Apply padding between the splints and all bony areas.				
	4. Place splits on opposite sides of the arm, so they do not lie on top of the suspected fracture.				
	5. Use at least four ties (two above and two below the fracture) to secure the splints.				
	6. Tie nonslip knots on the splint away from the injury.				
	7. Check the splint for tightness. A fingertip check should be made by inserting the tip of the finger between the bandaged knot and the skin.				
	8. Immobilize the splinted arm using a sling and/or swathes, as required, to prevent easy movement.				
	9. Check pulse to ensure there is still blood circulation below the fracture after applying the splints.				
	10. Watch the casualty for life-threatening conditions and check for other injuries. Seek medical aid; check and treat for shock. (NOTE: A leading question may be required to elicit a response or check understanding.)				

√ = step done correctly GO Yes No # Attempts _____ # Steps Not Attempted______ # Proper Corrections_____
X = step done incorrectly # Over Corrections_____ 1st Step Error______ Total Errors_______ Total Time _____

Control Bleeding Skills Assessment

1. Rank: ________ and MOS __________
2. Besides IET, have you received other medical training? (military, civilian, Scouting)? YES NO; if YES, explain:

____

____

____

Read test instructions. Note start time.

	Performance Steps	1st	2nd	3rd	4th
	***** State - Arterial bleeding is observed.**				
	1. Uncover the wound unless clothing is stuck to the wound or a chemical environment exists.				
	2. Apply the casualty's field dressing, white side down, directly over the wound.				
	3. Wrap the tails around the injury; ensure wraps cover the sterile white dressing.				
	4. Tie the tails securely in a non-slip knot.				
	5. Ensure knot is over the outer edge of the dressing (knot NOT on top of wound).				
	6. Check to make sure that knot is tied firmly enough to prevent slipping, yet not tight enough to stop normal circulation to the hand.				
	***** State - Arterial bleeding continues after field dressing is applied.**				
	7. Fold material as needed to form a pressure dressing (wad or pad).				
	8. Place wad on top of the field dressing directly over the wound.				
	9. Wrap a cravat (or other appropriate material) tightly around the wad and limb.				
	10. Tie a nonslip knot.				
	11. Ensure knot is directly over the wound to secure the wad.				
	12. Check the casualty's blood circulation below the pressure dressing. (You should be able to insert only one fingertip under the knot of the pressure dressing.) Loosen and retie the cravat if circulation is impaired.				
	***** State - Wad is secure, but the bandage does not stop blood circulation to the extremity.**				
	13. Apply direct manual pressure over the pressure dressing.				

√ = step done correctly GO Yes No # Attempts _____ # Steps Not Attempted______ # Proper Corrections_____
X = step done incorrectly # Over Corrections_____ 1st Step Error______ Total Errors_______ Total Time _____

Appendix E

Performance Checklists from Experiment 2

Map Reading Assessment Fade Condition

1. Rank: ________ MOS __________
2. Have you ever been taught how to determine location by resection? YES NO
3. Besides IET, what other map reading or land navigation training have you received (military, orienteering, Scouting)?

____

____

____

Read test instructions. Note start time.

	Performance Steps	**1st**	**2nd**	**3rd**	**4th**
	1. Identify the GM angle (21^o).				
	2. Determine if add or subtract for magnetic to grid conversion (add).				
	3. Convert 09^o magnetic azimuth to a grid azimuth (30^o).				
	4. Determine the back azimuth (210^o).				
	5. Position the protractor with the correct side facing up.				
	6. Position the protractor with 0^o to the North (top) and 90^o to the East (right).				
	7. Position the protractor with the intersection of the base and index lines on Point 1.				
	8. Use the protractor to indicate the correct degrees for the back azimuth.				
	9. Draw the back azimuth line.				
	10. Convert 29^o magnetic azimuth to a grid azimuth (50^o).				
	11. Determine the back azimuth (230^o).				
	12. Position the protractor with the correct side facing up.				
	13. Position the protractor with 0^o to the North (top) and 90^o to the East (right).				
	14. Position the protractor with the intersection of the base and index lines on Point 2.				
	15. Use the protractor to indicate the correct degrees for the back azimuth.				
	16. Draw the back azimuth line.				
	17. Identify the location (crest of Hill 130) within +/- 200 meters.				

√ = step done correctly GO Yes No # Attempts _____ # Steps Not Attempted______ # Proper Corrections_____
X = step done incorrectly # Over Corrections_____ 1st Step Error______ Total Errors_______ Total Time ______

Map Reading Assessment Blocked Condition

1. Rank: ________ MOS __________
2. Have you ever been taught how to determine location by resection? YES NO
3. Besides IET, what other map reading or land navigation training have you received (military, orienteering, Scouting)?

____

____

____

Read test instructions. Note start time.

	Performance Steps	1st	2nd	3rd	4th
Exam	1. Identify the GM angle (21^{o}).				
	2. Determine if add or subtract for magnetic to grid conversion (add).				
	3. Convert 09^{o} magnetic azimuth to a grid azimuth (30^{o}).				
	4. Determine the back azimuth (210^{o}).				
	5. Position the protractor with the correct side facing up.				
	6. Position the protractor with 0^{o} to the North (top) and 90^{o} to the East (right).				
	7. Position the protractor with the intersection of the base and index lines on Point 1.				
	8. Use the protractor to indicate the correct degrees for the back azimuth.				
	9. Draw the back azimuth line.				
Block Trial 4	10. Convert 29^{o} magnetic azimuth to a grid azimuth (50^{o}).				
	11. Determine the back azimuth (230^{o}).				
Block Trial 3	12. Position the protractor with the correct side facing up.				
	13. Position the protractor with 0^{o} to the North (top) and 90^{o} to the East (right).				
	14. Position the protractor with the intersection of the base and index lines on Point 2.				
Block Trial 2	15. Use the protractor to indicate the correct degrees for the back azimuth.				
	16. Draw the back azimuth line.				
	17. Identify the location (crest of Hill 130) within +/- 200 meters.				

√ = step done correctly GO Yes No # Attempts _____ # Steps Not Attempted______ # Proper Corrections_____
X = step done incorrectly # Over Corrections_____ 1st Step Error______ Total Errors_______ Total Time ______

Rappel Seat Assessment Fade Condition

1. Rank: ________ and MOS __________
2. Have you received other knot tying training? (military, mountaineering, Scouting)? YES NO ; if YES, explain

____
____
____

Read test instructions. Note start time.

	Performance Steps	**1st**	**2nd**	**3rd**	**4th**
	1. Find the middle of the sling rope and make a bight.				
	2. Decide which hand will be used as the brake hand (strong side hand) and place the bight on the opposite hip.				
	3. Reach around behind and grab a single strand of rope (trailing free end). Bring it around the waist to the front and make two overhand twists/loops on the other strand of rope, thus creating a loop around the waist.				
	4. Pass the two ends between the legs, ensuring they do not cross.				
	5. On the backside of the body, pass 1 end (left or right) up under the loop around the waist, bisecting the back pocket flap on the trousers.				
	6. On the backside of the body, pass 1 end (left or right) up under the loop around the waist, bisecting the back pocket flap on the trousers.				
	7. Pull up on both ropes (while squatting slightly), tightening the seat.				
	8. Pass one rope end (left or right) through the leg loop from rear to front creating a half hitch on hip.				
	9. Pass one rope end (left or right) through the leg loop from rear to front creating a half hitch on hip.				
	10. Bring the longer of the two ends across the front to the non-brake hand hip.				
	11. Holding one working end in each hand, place the working end in the right hand over the one in the left hand. (Note: Steps 11-14 are tying the square knot.)				
	12. Pull it under and back over the top of the rope in the left hand.				
	13. Place the working end in the left hand over the one in the right hand				
	14. Pull it under and back over the top of the rope in the right hand.				
	15. Dress the knot down.				
	16. On one side (left or right) of the square knot, tie a half hitch knot.				
	17. On other side (left or right) of the square knot, tie a half hitch knot.				
	18. Ensure 4 inches of rope protrudes past each half-hitch.				
	19. Tuck any excess rope in the pocket below the square knot.				

√ = step done correctly GO Yes No # Attempts _____ # Steps Not Attempted______ # Proper Corrections_____
X = step done incorrectly # Over Corrections_____ 1st Step Error______ Total Errors_______ Total Time ____

Rappel Seat Assessment Block Condition

1. Rank: ________ and MOS __________
2. Have you received other knot tying training? (military, mountaineering, Scouting)? YES NO ; if YES, explain

____

____

____

Read test instructions. Note start time.

	Performance Steps	1st	2nd	3rd	4th
Exam	1. Find the middle of the sling rope and make a bight.				
	2. Decide which hand will be used as the brake hand (strong side hand) and place the bight on the opposite hip.				
	3. Reach around behind and grab a single strand of rope (trailing free end). Bring it around the waist to the front and make two overhand twists/loops on the other strand of rope, thus creating a loop around the waist.				
	4. Pass the two ends between the legs, ensuring they do not cross.				
	5. On the backside of the body, pass 1 end (left or right) up under the loop around the waist, bisecting the back pocket flap on the trousers.				
	6. On the backside of the body, pass 1 end (left or right) up under the loop around the waist, bisecting the back pocket flap on the trousers.				
Block Trial 4	7. Pull up on both ropes (while squatting slightly), tightening the seat.				
	8. Pass one rope end (left or right) through the leg loop from rear to front creating a half hitch on hip.				
	9. Pass one rope end (left or right) through the leg loop from rear to front creating a half hitch on hip.				
	10. Bring the longer of the two ends across the front to the non-brake hand hip.				
	11. Holding one working end in each hand, place the working end in the right hand over the one in the left hand. (Note: Steps 11-14 are tying the square knot.)				
Block Trial 3	12. Pull it under and back over the top of the rope in the left hand.				
	13. Place the working end in the left hand over the one in the right hand				
	14. Pull it under and back over the top of the rope in the right hand.				
	15. Dress the knot down.				
	16. On one side (left or right) of the square knot, tie a half hitch knot.				
	17. On other side (left or right) of the square knot, tie a half hitch knot.				
Block Trial 2	18. Ensure 4 inches of rope protrudes past each half-hitch.				
	19. Tuck any excess rope in the pocket below the square knot.				

√ = step done correctly GO Yes No # Attempts _____ # Steps Not Attempted______ # Proper Corrections_____
X = step done incorrectly # Over Corrections_____ 1^{st} Step Error______ Total Errors_______ Total Time ____

Appendix F

Descriptive Statistics by Task

Table F-1
Go Rates by Task

'Go' Rates	Tasks						
	Hand Cuff	Rappel	Fracture	Bleed	Step Fade Map	Block Fade Map	Block Fade Rappel
'No Go'	1	3	3	8	9	10	7
'Go'	29	27	27	22	23	23	23

Table F-2
Unattempted Steps by Task

Unattempted Steps	Tasks						
	Hand Cuff	Rappel	Fracture	Bleed	Step Fade Map	Block Fade Map	Block Fade Rappel
0	30	29	30	30	29	32	28
6	0	0	0	0	1	0	1
7	0	0	0	0	0	1	0
10	0	1	0	0	0	0	0
13	0	0	0	0	0	0	1
16	0	0	0	0	2	0	0

Table F-3
Proper Corrections by Task

Proper Corrections	Tasks						
	Hand Cuff	Rappel	Fracture	Bleed	Step Fade Map	Block Fade Map	Block Fade Rappel
0	27	20	30	29	28	26	24
1	3	8	0	1	4	5	5
2	0	2	0	0	0	1	1
4	0	0	0	0	0	1	0

Table F-4
Overcorrections by Task

Proper Corrections	Tasks						
	Hand Cuff	Rappel	Fracture	Bleed	Step Fade Map	Block Fade Map	Block Fade Rappel
0	27	27	30	30	32	32	27
1	2	3	0	0	0	1	3
2	1	0	0	0	0	0	0

Table F-5
First Step Error by Task

Step Number	Tasks						
	Hand Cuff	Rappel	Fracture	Bleed	Step Fade Map	Block Fade Map	Block Fade Rappel
0	24	17	27	22	21	17	18
1	0	0	0	0	2	0	0
2	0	1	1	0	0	0	0
3	0	0	0	1	0	1	1
4	2	1	1	0	3	5	2
5	0	0	0	0	0	1	0
6	2	0	0	0	0	0	0
7	0	1	1	0	0	0	1
8	2	0	0	0	0	3	2
9	0	0	0	0	1	0	0
10	0	3	0	0	2	2	0
11	0	1	0	0	0	1	0
12	0	2	0	2	0	0	3
13	0	1	0	2	0	0	3
14	0	2	0	0	0	0	0
15	0	0	0	0	2	2	0
16	0	0	0	2	1	1	0
17	0	1	0	0	0	0	0
20	0	0	0	1	0	0	0

Table F-6
Total Errors by Task

Total Errors	Tasks						
	Hand Cuff	Rappel	Fracture	Bleed	Step Fade Map	Block Fade Map	Block Fade Rappel
0	24	17	27	22	21	17	18
1	0	0	0	0	2	0	0
2	0	1	1	0	0	0	0
3	0	0	0	1	0	1	1
4	2	1	1	0	3	5	2
5	0	0	0	0	0	1	0
7	0	1	1	0	0	0	1
9	0	0	0	0	1	0	0
15	0	0	0	0	2	2	0

Table F-7
Means and Standard Deviations of Time by Task

Task	N	Mean	SD	Min	Max
Hand Cuff	30	76.60	34.27	42.00	200.00
Rappel	30	89.83	18.53	48.00	122.00
Fracture	30	189.67	33.11	129.00	270.00
Bleed	30	195.37	37.30	149.00	272.00
(Step) Map	32	218.22	99.12	110.00	470.00
(Block) Map	33	207.12	64.59	95.00	375.00
(Block) Rappel	30	99.53	67.33	45.00	430.00

Appendix G

Statistical Tests from Experiment 1

Table G-1
Chi-Square for Go Rate: Hand Cuff (Knot Tying) vs. Rappel (Knot Tying)

	Hand Cuff (Knot Tying)		Rappel (Knot Tying)	
'Go' Rate	Expected	Observed	Expected	Observed
No	2	1	2	3
Yes	28	29	28	27
Pearson Chi-Square (1, 60) = .30				

Table G-2
Chi-Square for Unattempted Steps: Hand Cuff (Knot Tying) vs. Rappel (Knot Tying)

	Hand Cuff (Knot Tying)		Rappel (Knot Tying)	
Unattempted Steps	Expected	Observed	Expected	Observed
0	29.5	30	29.5	29
1 or more	.5	0	.5	1
Pearson Chi-Square (1, 60) = .31				

Table G-3
Chi-Square for Total Errors: Hand Cuff (Knot Tying) vs. Rappel (Knot Tying)

	Hand Cuff (Knot Tying)		Rappel (Knot Tying)	
Total Errors	Expected	Observed	Expected	Observed
0	20.5	24	20.5	17
1 or more	9.5	6	9.5	13
Pearson Chi-Square (1, 60) = .05				

Table G-4
Independent Samples t-test for Time: Hand Cuff (Knot Tying) vs. Rappel (Knot Tying)

Hand Cuff (Knot Tying)		Rappel (Knot Tying)	
M	SD	M	SD
76.60	34.27	89.83	18.53
t (1, 58) = .07			

Table G-5
Chi-Square for Attempts: Hand Cuff (Knot Tying) vs. Rappel (Knot Tying)

	Hand Cuff (Knot Tying)		Rappel (Knot Tying)	
Attempts	Expected	Observed	Expected	Observed
1	21	24	21	18
2 or More	9	6	9	12
Pearson Chi-Square (1, 60) = .09				

Table G-6
Chi-Square for Proper Corrections: Hand Cuff (Knot Tying) vs. Rappel (Knot Tying)

	Hand Cuff (Knot Tying)		Rappel (Knot Tying)	
Proper Corrections	Expected	Observed	Expected	Observed
0	23.5	27	23.5	20
1 or more	6.5	3	6.5	10
Pearson Chi-Square (1, 60) = .03				

Table G-7
Chi-Square for Overcorrections: Hand Cuff (Knot Tying) vs. Rappel (Knot Tying)

	Hand Cuff (Knot Tying)		Rappel (Knot Tying)	
Proper Corrections	Expected	Observed	Expected	Observed
0	27	27	27	27
1 or more	3	3	3	3
Pearson Chi-Square N/A. (No variance.)				

Table G-8
Chi-Square for Go Rate: Fracture (First Aid) vs. Bleed (First Aid)

	Fracture (First Aid)		Bleed (First Aid)	
'Go' Rate	Expected	Observed	Expected	Observed
No	5.5	3	5.5	8
Yes	24.5	27	24.5	22
Pearson Chi-Square (1, 60) = .10				

Table G-9
Chi-Square for Unattempted Steps: Fracture (First Aid) vs. Bleed (First Aid)

	Fracture (First Aid)		Bleed (First Aid)	
Unattempted Steps	Expected	Observed	Expected	Observed
0	30	30	30	30
1 or more	0	0	0	0
Pearson Chi-Square N/A				

Table G-10
Chi-Square for Total Errors: Fracture (First Aid) vs. Bleed (First Aid)

	Fracture (First Aid)		Bleed (First Aid)	
Total Errors	Expected	Observed	Expected	Observed
0	24.5	27	24.5	22
1 or more	5.5	3	5.5	8
Pearson Chi-Square (1, 60) = .10				

Table G-11
Independent Samples t-test for Time: Fracture (First Aid) vs. Bleed (First Aid)

Fracture (First Aid)		Bleed (First Aid)	
M	SD	M	SD
189.67	33.11	195.37	37.30
t (1, 58) = .53			

Table G-12
Chi-Square for Attempts: Fracture (First Aid) vs. Bleed (First Aid)

	Fracture (First Aid)		Bleed (First Aid)	
Attempts	Expected	Observed	Expected	Observed
1	29.5	30	29.5	29
2 or More	.5	0	.5	1
Pearson Chi-Square (1, 60) = .31				

Table G-13
Chi-Square for Proper Corrections: Fracture (First Aid) vs. Bleed (First Aid)

	Fracture (First Aid)		Bleed (First Aid)	
Proper Corrections	Expected	Observed	Expected	Observed
0	23.5	27	23.5	20
1 or more	6.5	3	6.5	10
Pearson Chi-Square (1, 60) = .31				

Table G-14
Chi-Square for Overcorrections: Fracture (First Aid) vs. Bleed (First Aid)

	Fracture (First Aid)		Bleed (First Aid)	
Proper Corrections	Expected	Observed	Expected	Observed
0	30	30	30	30
1 or more	0	0	0	0
Pearson Chi-Square N/A*				

*Note: N/A because no variance.

Appendix H

Statistical Tests from Experiment 2

Table H-1
Chi-Square for 'Go' Rate: Step Fade Map Reading vs. Block Fade Map Reading

	Step Fade Map Reading		Block Fade Map Reading	
'Go' Rate	Expected	Observed	Expected	Observed
No	9.4	9	9.6	10
Yes	22.6	23	23.4	23
Pearson Chi-Square (1, 65) = .85				

Table H-2
Chi-Square for Unattempted Steps: Step Fade Map Reading vs. Block Fade Map Reading

	Step Fade Map Reading		Block Fade Map Reading	
Unattempted Steps	Expected	Observed	Expected	Observed
0	30	29	31	32
1 or more	1	3	2	1
Pearson Chi-Square (1, 65) = .29				

Table H-3
Chi-Square for Total Errors: Step Fade Map Reading vs. Block Fade Map Reading

	Step Fade Map Reading		Block Fade Map Reading	
Total Errors	Expected	Observed	Expected	Observed
0	18.7	21	19.3	17
1 or more	13.3	11	13.7	16
Pearson Chi-Square (1, 65) = .25				

Table H-4
Independent Samples t-test for Time: Step Fade Map Reading vs. Block Fade Map Reading

Step Fade Map Reading		Block Fade Map Reading	
M	SD	M	SD
218.22	99.12	207.12	64.60
t (1, 63) = .59			

Table H-5
Chi-Square for Attempts: Step Fade Map Reading vs. Block Fade Map Reading

	Step Fade Map Reading		Block Fade Map Reading	
Attempts	Expected	Observed	Expected	Observed
1	25.1	28	25.9	23
2 or More	6.9	4	7.1	10
Pearson Chi-Square (1, 65) = .08				

Table H-6
Chi-Square for Proper Corrections: Step Fade Map Reading vs. Block Fade Map Reading

	Step Fade Map Reading		Block Fade Map Reading	
Proper Corrections	Expected	Observed	Expected	Observed
0	26.6	28	27.4	26
1 or more	5.4	4	5.6	7
Pearson Chi-Square (1, 65) = .35				

Table H-7
Chi-Square for Overcorrections: Step Fade Map Reading vs. Block Fade Map Reading

	Step Fade Map Reading		Block Fade Map Reading	
Proper Corrections	Expected	Observed	Expected	Observed
0	31.5	32	32.5	32
1 or more	.5	0	.5	1
Pearson Chi-Square (1, 65) = .32				

Table H-8
Chi-Square for 'Go' Rate: Step Fade Rappel vs. Block Fade Rappel

	Step Fade Rappel		Block Fade Rappel	
'Go' Rate	Expected	Observed	Expected	Observed
No	5	3	5	7
Yes	25	27	25	23
Pearson Chi-Square (1, 60) = .17				

Table H-9
Chi-Square for Unattempted Steps: Step Fade Rappel vs. Block Fade Rappel

	Step Fade Rappel		Block Fade Rappel	
Unattempted Steps	Expected	Observed	Expected	Observed
0	28.5	29	28.5	28
1 or more	1.5	1	1.5	2
Pearson Chi-Square (1, 60) =.55				

Table H-10
Chi-Square for Total Errors: Step Fade Rappel vs. Block Fade Rappel

	Step Fade Rappel		Block Fade Rappel	
Total Errors	Expected	Observed	Expected	Observed
0	17.5	17	17.5	18
1 or more	12.5	13	12.5	12
Pearson Chi-Square (1, 60) = .79				

Table H-11
Independent Samples t-test for Time: Step Fade Rappel vs. Block Fade Rappel

Step Fade Rappel		Block Fade Rappel	
M	SD	M	SD
89.33	18.53	99.53	67.33
t (1, 58) = .45			

Table H-12
Chi-Square for Attempts: Step Fade Rappel vs. Block Fade Rappel

	Step Fade Rappel		Block Fade Rappel	
Attempts	Expected	Observed	Expected	Observed
1	19.5	18	19.5	21
2 or More	10.5	12	10.5	9
Pearson Chi-Square (1, 60) = .42				

Table H-13
Chi-Square for Proper Corrections: Step Fade Rappel vs. Block Fade Rappel

	Step Fade Rappel		Block Fade Rappel	
Proper Corrections	Expected	Observed	Expected	Observed
0	22	20	22	24
1 or more	8	10	8	6
Pearson Chi-Square (1, 60) = .24				

Table H -14
Chi-Square for Overcorrections: Fracture (First Aid) vs. Bleed (First Aid)

	Step Fade Rappel		Block Fade Rappel	
Proper Corrections	Expected	Observed	Expected	Observed
0	27	27	27	27
1 or more	3	3	3	3
Pearson Chi-Square N/A*				

*Note: N/A because no variance.